# Programming Assignment #1

Operating Systems (SCE213)

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# PA1

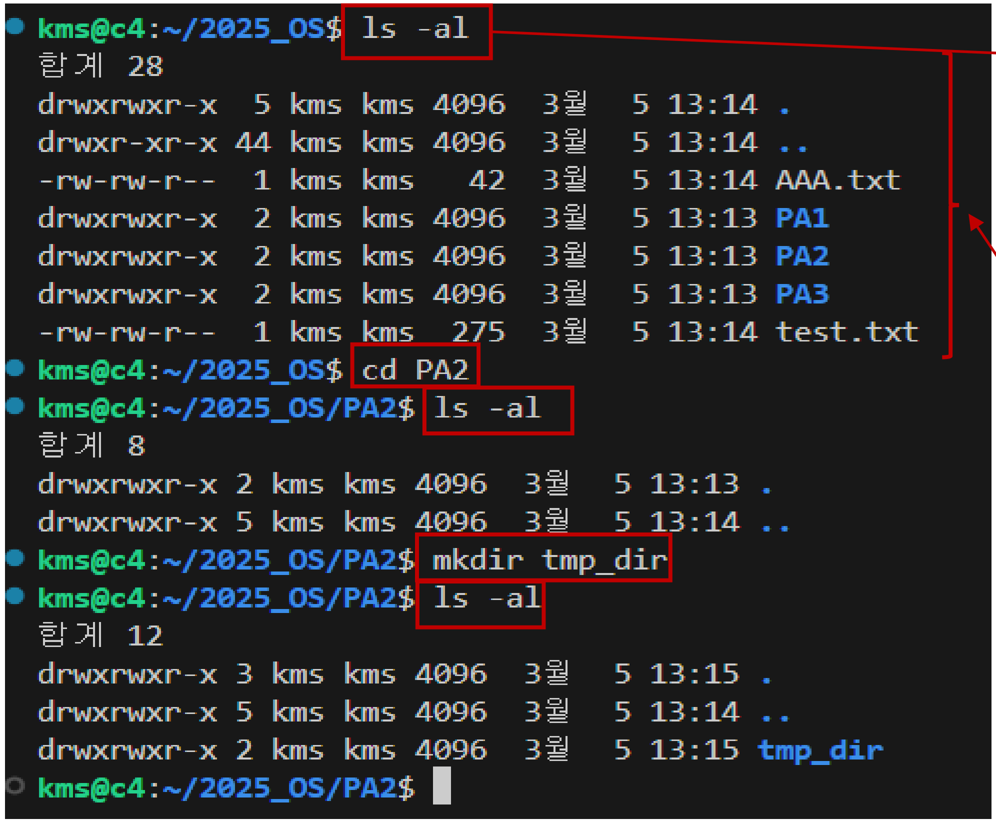
- In PA1, you are going to implement a “mini” shell

- The contents of this PA includes
  1. Basic Linux commands
  2. Basic C(system call function)
  3. Process creation and termination
  4. IPC using |(pipe)

- Following contents include some backgrounds and hints for this PA

# Shell

- Shell is a command-line interface(CLI) that allows users to interact with the operating system(Linux, Windows, etc…)

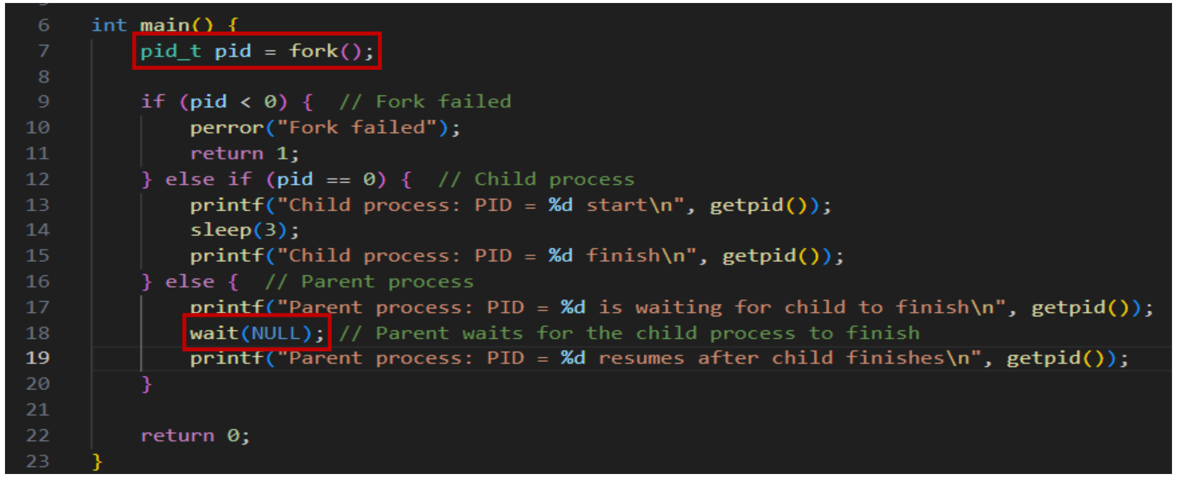


```
kms@c4:~/2025_OS$ ls -al
합계 28
drwxrwxr-x  5 kms kms 4096  3월   5 13:14 .
drwxr-xr-x 44 kms kms 4096  3월   5 13:14 ..
-rw-rw-r--  1 kms kms   42  3월   5 13:14 AAA.txt
drwxrwxr-x  2 kms kms 4096  3월   5 13:13 PA1
drwxrwxr-x  2 kms kms 4096  3월   5 13:13 PA2
drwxrwxr-x  2 kms kms 4096  3월   5 13:13 PA3
-rw-rw-r--  1 kms kms  275  3월   5 13:14 test.txt
kms@c4:~/2025_OS$ cd PA2
kms@c4:~/2025_OS/PA2$ ls -al
합계 8
drwxrwxr-x 2 kms kms 4096  3월   5 13:13 .
drwxrwxr-x 5 kms kms 4096  3월   5 13:14 ..
kms@c4:~/2025_OS/PA2$ mkdir tmp_dir
kms@c4:~/2025_OS/PA2$ ls -al
합계 12
drwxrwxr-x 3 kms kms 4096  3월   5 13:15 .
drwxrwxr-x 5 kms kms 4096  3월   5 13:14 ..
drwxrwxr-x 2 kms kms 4096  3월   5 13:15 tmp_dir
kms@c4:~/2025_OS/PA2$ 
```

1. User types command
2. Shell reads command
3. Shell creates a new process and executes the command using created process
4. Shell waits for the process to complete
5. Show the result of executed command

# Process

- You can create a new child process using fork() system call
  - fork() returns
    - ☆ 0 to the child process
    - ☆ child’s process ID(PID) to the parent process
    - ☆ -1 if the fork fails
- You can make parent process to wait for one of its child processes to terminate using wait() system call

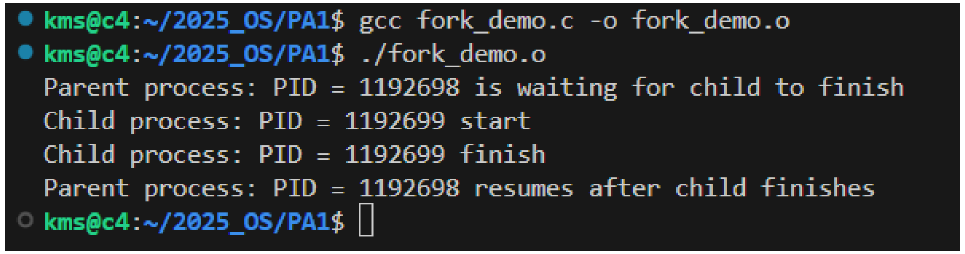


```c
int main() {
    pid_t pid = fork();

    if (pid < 0) {  // Fork failed
        perror("Fork failed");
        return 1;
    } else if (pid == 0) {  // Child process
        printf("Child process: PID = %d start\n", getpid());
        sleep(3);
        printf("Child process: PID = %d finish\n", getpid());
    } else {  // Parent process
        printf("Parent process: PID = %d is waiting for child to finish\n", getpid());
        wait(NULL); // Parent waits for the child process to finish
        printf("Parent process: PID = %d resumes after child finishes\n", getpid());
    }

    return 0;
}
```

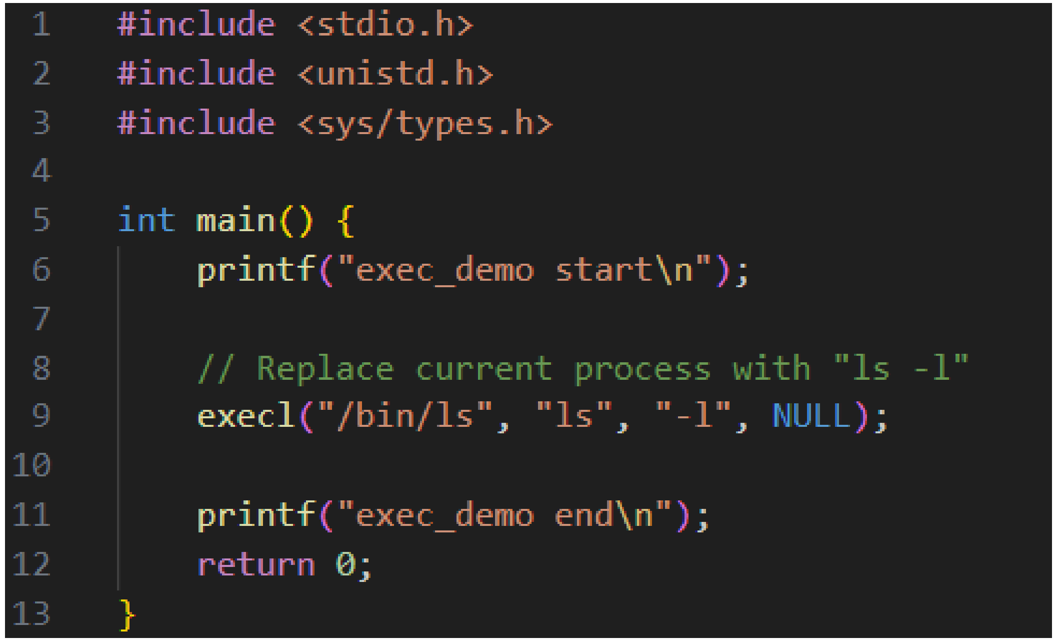
- Try running the left code.



```
kms@c4:~/2025_OS/PA1$ gcc fork_demo.c -o fork_demo.o
kms@c4:~/2025_OS/PA1$ ./fork_demo.o
Parent process: PID = 1192698 is waiting for child to finish
Child process: PID = 1192699 start
Child process: PID = 1192699 finish
Parent process: PID = 1192698 resumes after child finishes
kms@c4:~/2025_OS/PA1$
```

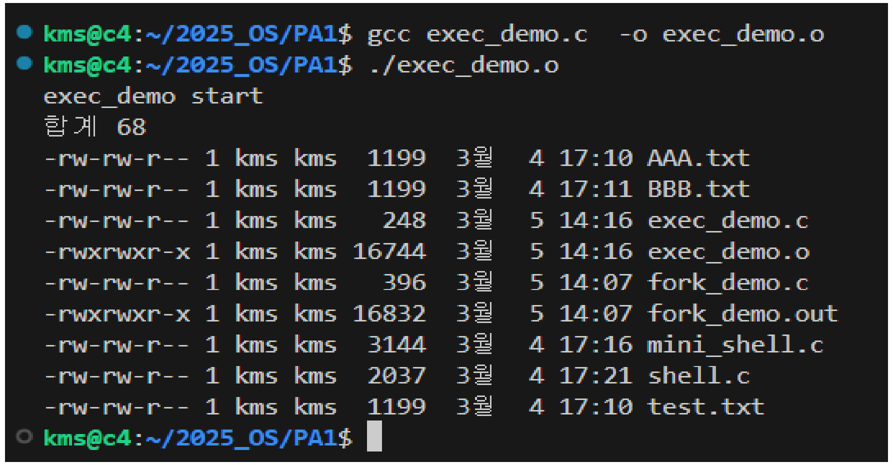
# Process

- You can replace the current process with a new process using exec() system call family
  - exec() does not create a new process
  - exec() loads and executes a specified program within the same(current) process ID



```
1   #include <stdio.h>
2   #include <unistd.h>
3   #include <sys/types.h>
4
5   int main() {
6       printf("exec_demo start\n");
7
8       // Replace current process with "ls -l"
9       execl("/bin/ls", "ls", "-l", NULL);
10
11      printf("exec_demo end\n");
12      return 0;
13  }
```

- Try running the left code.
- Note that function “printf()” at line 11 is not executed.



```
kms@c4:~/2025_OS/PA1$ gcc exec_demo.c  -o exec_demo.o
kms@c4:~/2025_OS/PA1$ ./exec_demo.o
exec_demo start
합계 68
-rw-rw-r-- 1 kms kms  1199  3월  4 17:10 AAA.txt
-rw-rw-r-- 1 kms kms  1199  3월  4 17:11 BBB.txt
-rw-rw-r-- 1 kms kms   248  3월  5 14:16 exec_demo.c
-rwxrwxr-x 1 kms kms 16744  3월  5 14:16 exec_demo.o
-rw-rw-r-- 1 kms kms   396  3월  5 14:07 fork_demo.c
-rwxrwxr-x 1 kms kms 16832  3월  5 14:07 fork_demo.out
-rw-rw-r-- 1 kms kms  3144  3월  4 17:16 mini_shell.c
-rw-rw-r-- 1 kms kms  2037  3월  4 17:21 shell.c
-rw-rw-r-- 1 kms kms  1199  3월  4 17:10 test.txt
kms@c4:~/2025_OS/PA1$ 
```

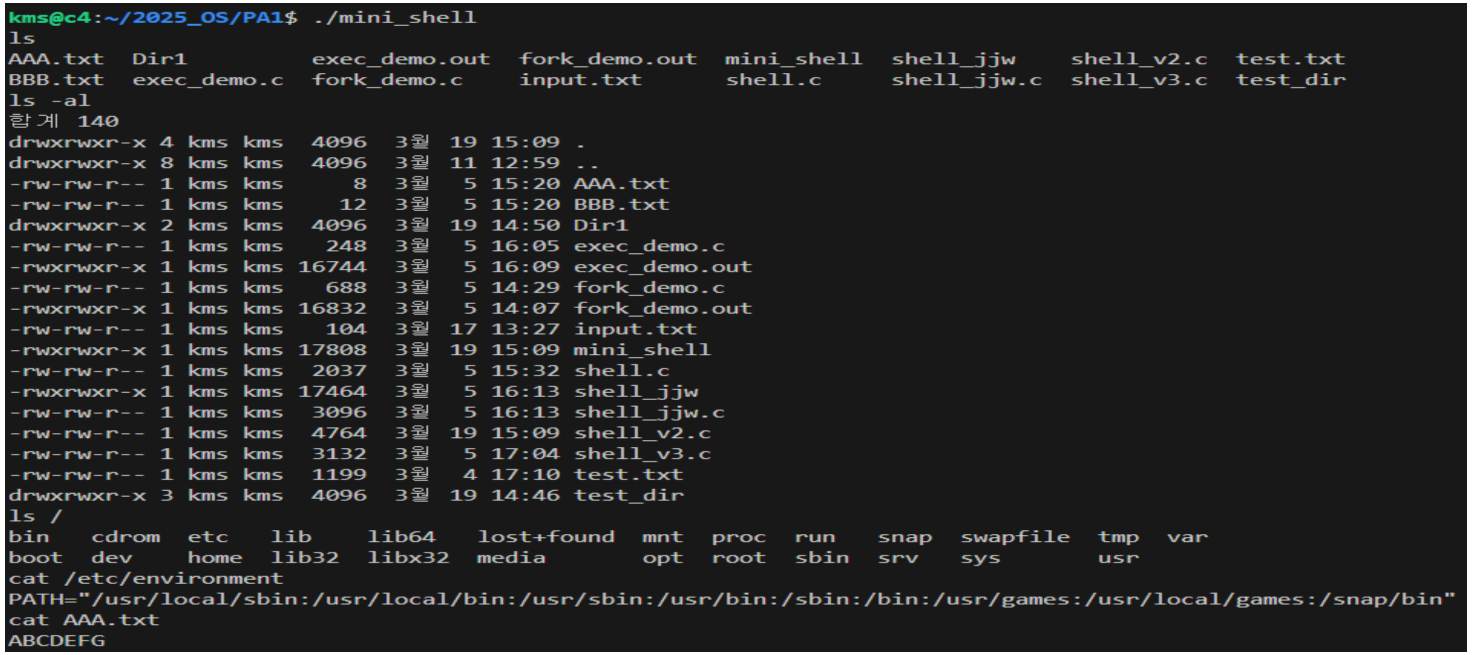
# To Do

- Implement “mini” shell which supports
  1. Some external commands (ls, cat, grep and etcs…)
  2. cd : Change current directory
  3. | (pipe) : Redirects the output of one process as the input to another process
  4. alias : Create shortcuts for longer commands by defining custom aliases

- Please read the attached **“PA1_spec”** document carefully for the detailed implementation specifications.

# To Do

- External commands(ls and cat)

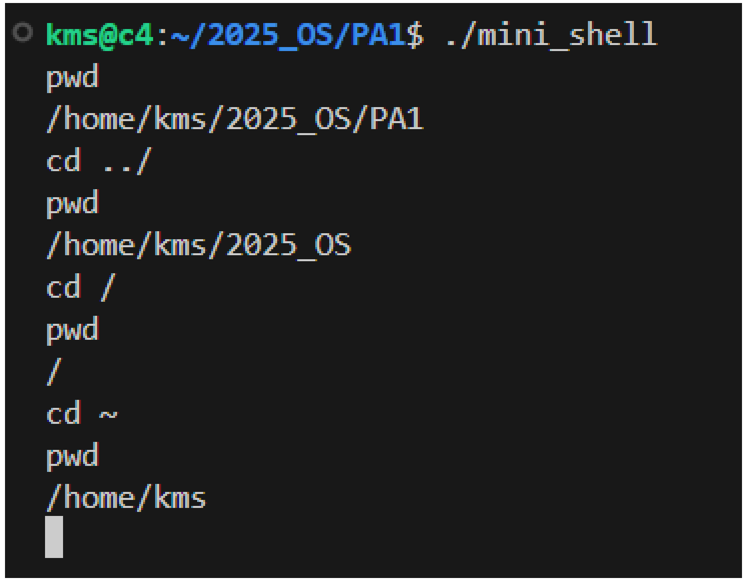


```
kms@c4:~/2025_OS/PA1$ ./mini_shell
ls
AAA.txt  Dir1          exec_demo.out  fork_demo.out  mini_shell  shell_jjw    shell_v2.c  test.txt
BBB.txt  exec_demo.c   fork_demo.c    input.txt      shell.c     shell_jjw.c  shell_v3.c  test_dir
ls -al
합계 140
drwxrwxr-x 4 kms kms  4096  3월 19 15:09 .
drwxrwxr-x 8 kms kms  4096  3월 11 12:59 ..
-rw-rw-r-- 1 kms kms     8  3월  5 15:20 AAA.txt
-rw-rw-r-- 1 kms kms    12  3월  5 15:20 BBB.txt
drwxrwxr-x 2 kms kms  4096  3월 19 14:50 Dir1
-rw-rw-r-- 1 kms kms   248  3월  5 16:05 exec_demo.c
-rwxrwxr-x 1 kms kms 16744  3월  5 16:09 exec_demo.out
-rw-rw-r-- 1 kms kms   688  3월  5 14:29 fork_demo.c
-rwxrwxr-x 1 kms kms 16832  3월  5 14:07 fork_demo.out
-rw-rw-r-- 1 kms kms   104  3월 17 13:27 input.txt
-rwxrwxr-x 1 kms kms 17808  3월 19 15:09 mini_shell
-rw-rw-r-- 1 kms kms  2037  3월  5 15:32 shell.c
-rwxrwxr-x 1 kms kms 17464  3월  5 16:13 shell_jjw
-rw-rw-r-- 1 kms kms  3096  3월  5 16:13 shell_jjw.c
-rw-rw-r-- 1 kms kms  4764  3월 19 15:09 shell_v2.c
-rw-rw-r-- 1 kms kms  3132  3월  5 17:04 shell_v3.c
-rw-rw-r-- 1 kms kms  1199  3월  4 17:10 test.txt
drwxrwxr-x 3 kms kms  4096  3월 19 14:46 test_dir
ls /
bin   cdrom  etc   lib    lib64   lost+found  mnt  proc  run   snap  swapfile  tmp  var
boot  dev    home  lib32  libx32  media       opt  root  sbin  srv   sys       usr
cat /etc/environment
PATH="/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin:/usr/games:/usr/local/games:/snap/bin"
cat AAA.txt
ABCDEFG
```

  - » All of external commands are located in “/usr/bin”  or “/bin”

# To Do

- cd command

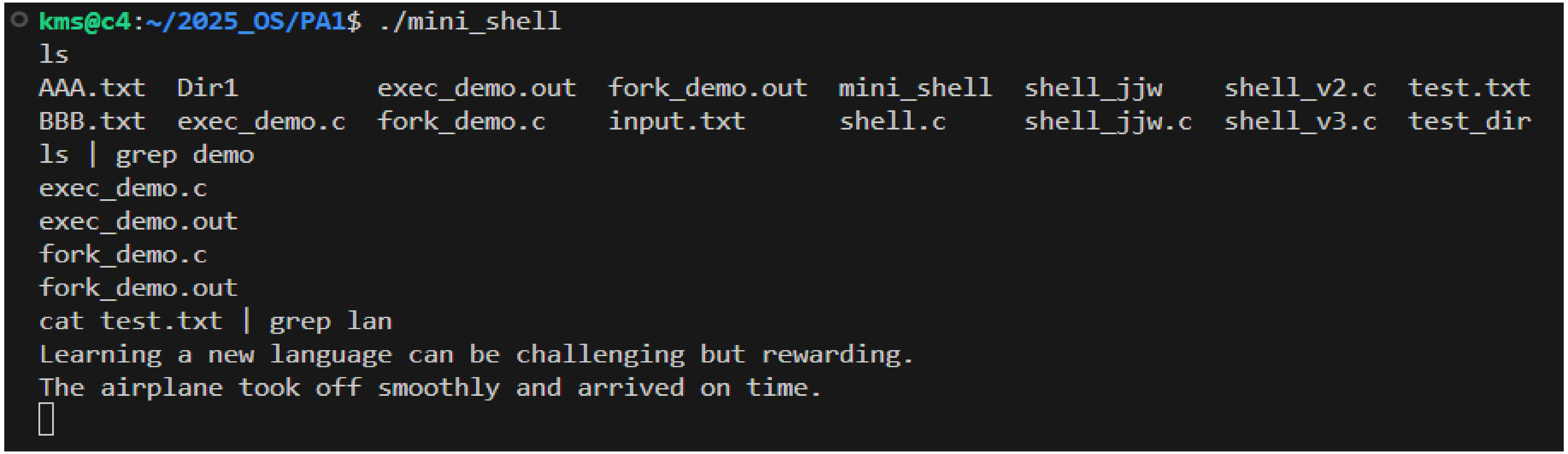


```
kms@c4:~/2025_OS/PA1$ ./mini_shell
pwd
/home/kms/2025_OS/PA1
cd ../
pwd
/home/kms/2025_OS
cd /
pwd
/
cd ~
pwd
/home/kms
```

  - “~” indicates the home directory of current user
  - Use chdir() and getenv(“HOME”)

# To Do

- |(pipe) command

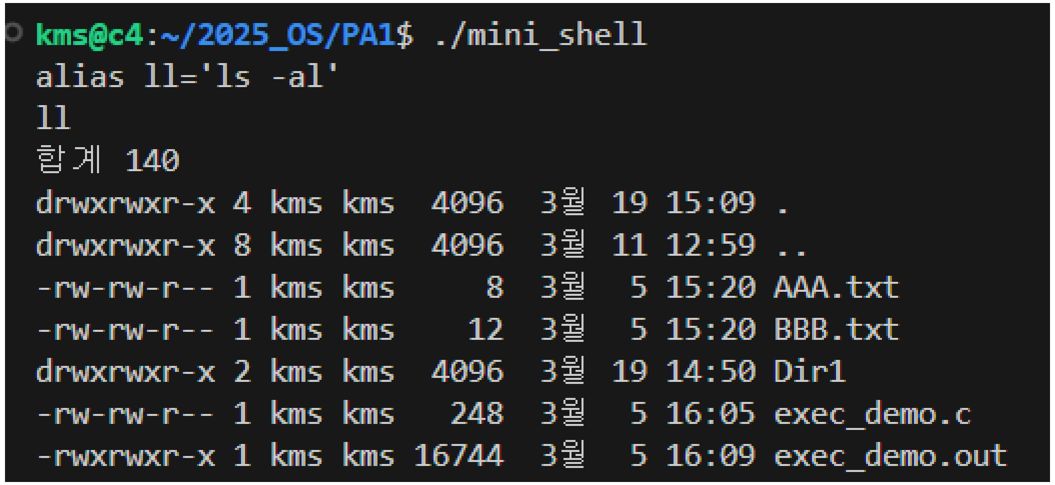


```
kms@c4:~/2025_OS/PA1$ ./mini_shell
ls
AAA.txt  Dir1         exec_demo.out  fork_demo.out  mini_shell  shell_jjw    shell_v2.c  test.txt
BBB.txt  exec_demo.c  fork_demo.c    input.txt      shell.c     shell_jjw.c  shell_v3.c  test_dir
ls | grep demo
exec_demo.c
exec_demo.out
fork_demo.c
fork_demo.out
cat test.txt | grep lan
Learning a new language can be challenging but rewarding.
The airplane took off smoothly and arrived on time.
```

  - A | B means use output of A as input of B
  - Use pipe() and dup2()

# To Do

- alias command



```
kms@c4:~/2025_OS/PA1$ ./mini_shell
alias ll='ls -al'
ll
합계 140
drwxrwxr-x 4 kms kms  4096  3월 19 15:09 .
drwxrwxr-x 8 kms kms  4096  3월 11 12:59 ..
-rw-rw-r-- 1 kms kms     8  3월  5 15:20 AAA.txt
-rw-rw-r-- 1 kms kms    12  3월  5 15:20 BBB.txt
drwxrwxr-x 2 kms kms  4096  3월 19 14:50 Dir1
-rw-rw-r-- 1 kms kms   248  3월  5 16:05 exec_demo.c
-rwxrwxr-x 1 kms kms 16744  3월  5 16:09 exec_demo.out
```

» alias name='commands' means setting name as a shortcut for commands

☆ alias ll='ls –al'

# Grading policy

- **We will provide all the test case examples that will be used for grading.**
  - **No additional test cases will be used.**
  - **Total 20 test cases. (5 points each)**

- Since the output of “mini_shell” may vary depending on the directory and file structure of the execution environment, reference outputs will not be provided

- You are expected to test your “mini_shell” by comparing its results with those from a real shell.
  - Refer the “self test” section in the specification document.

# Notice

- Duration
  - Start: 9/17 11:59 PM
  - End:  9/24 11:59 PM
  - Late Submission:  9/26 11:59PM
    - ☆ 25% penalty of final score of “this” assignment
    - ☆ After late submission, all of submissions will not be accepted

- Submission
  - Submit your single mini-shell source code named [StudentID].c
  - Ex) 202512345.c

# Notice

- QA
  - » For general question: Google QA Spreadsheet
    - ☆ https://docs.google.com/spreadsheets/d/1sFQfJBmQmL8oFcTwNPbJefb3Janst9uMZIDW_hM_nHI/edit?gid=683163501#gid=683163501
  - » For personal question: Subject e-mail
    - ☆ os.at.ajou@gmail.com
    - ☆ When sending an email, please follow the below policy

Entitle your emails with your subsection info and a concise description of your inquiries.

Include your name and Student ID in the email

Ex) Title: [OS] Question regarding assignment/lecture